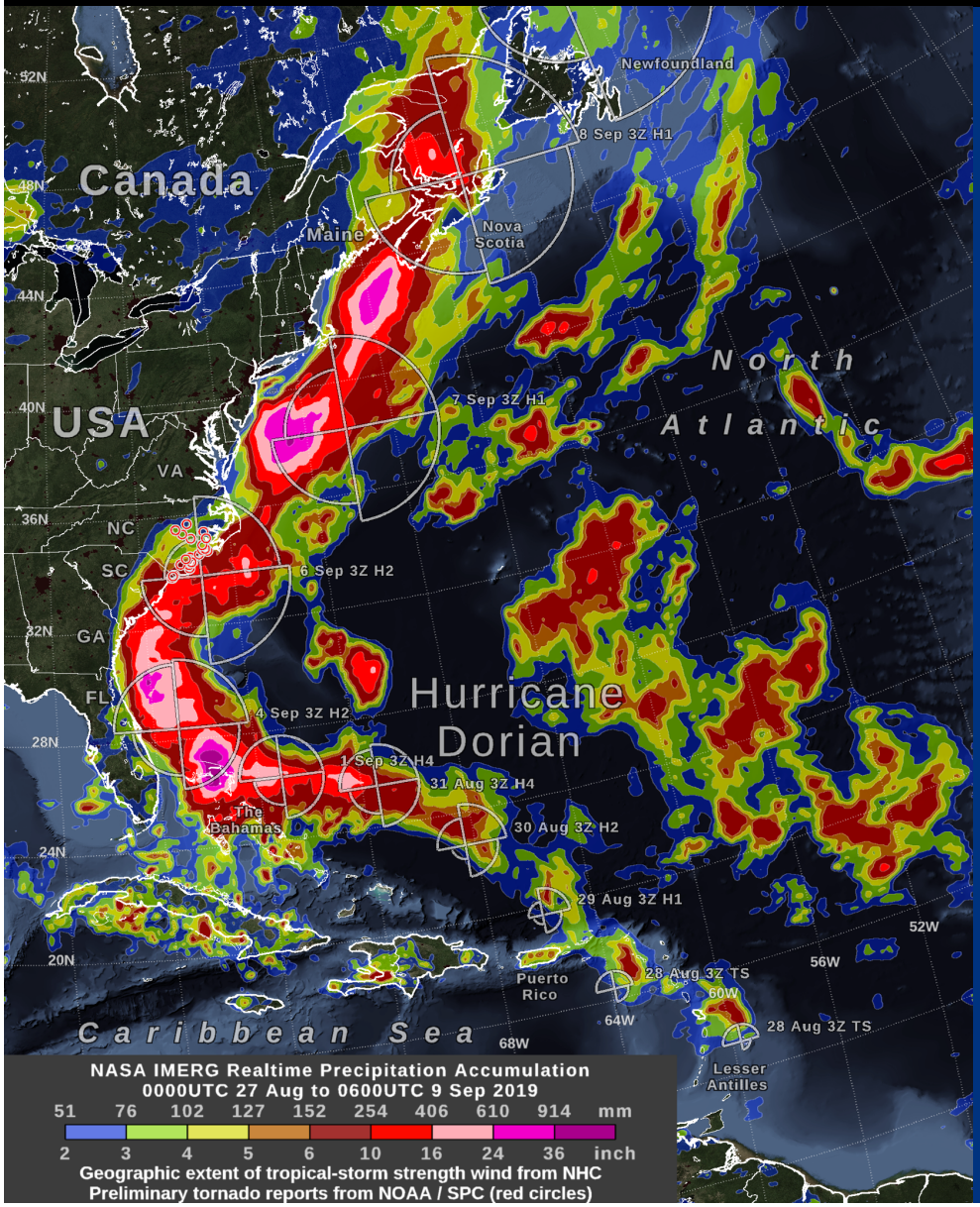
GPM Status and Science



Scott Braun
GPM Project Scientist

NASA Goddard Space Flight Center

Precipitation Measurement Missions Science Team Meeting
November 5, 2019

www.nasa.gov/gpm
Twitter: NASARain
Facebook: NASARain

Notes on Agenda

- 15 minute talks, hold questions until end-of-session discussion
- GV panel discussion
  - Connecting GV and algorithms
  - Four 7-minute talks followed by discussion
- Communications bootcamp Wed. 5-10 pm (Ask Dalia!)
- Ana Barros/Steve Nesbitt talks swapped between Wednesday and Thursday

The GPM Core Observatory

GLOBAL PRECIPITATION MEASUREMENT

GPM Core Observatory:

Launch: Feb. 27, 2014

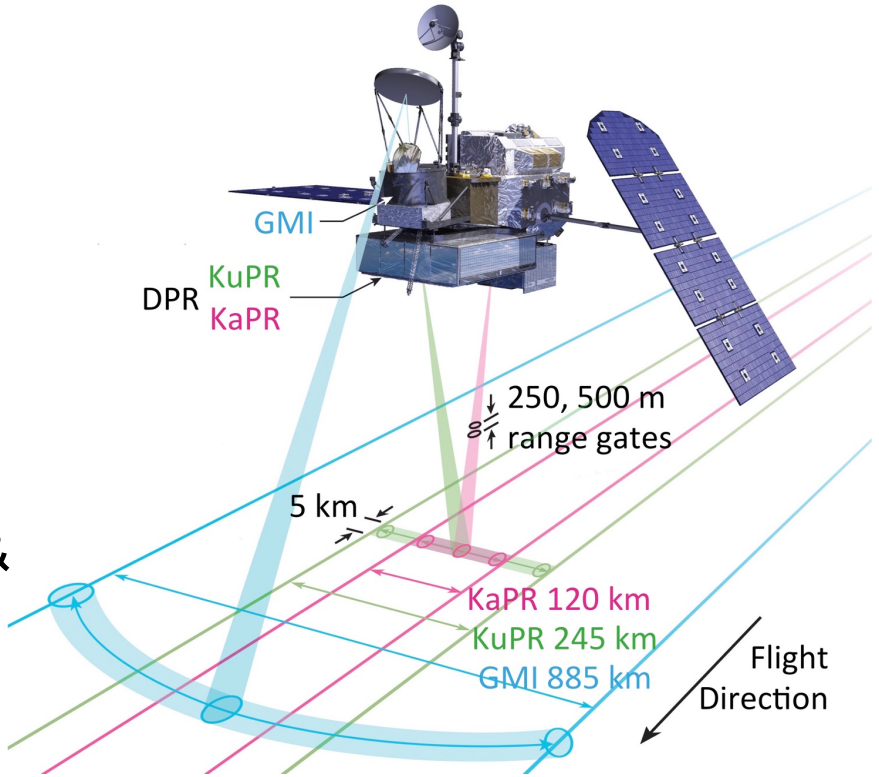
Altitude: 407 km

Orbit inclination: 65°

3-year design life, extra fuel

Measurement range: 0.2-110 mm/hr &

Snow detection



GPM Microwave Imager (GMI) 13 Channels, (Provided by NASA)

- Passive radiometer with excellent calibration
- 10VH, 19VH, 23, 36VH, 89VH, 166VH, 183±3, ±7
- Provides measurements of precipitation (rain and snow) intensity and distribution over 885 km swath
- High spatial resolution (down to ~5km footprints)

Dual-frequency Precipitation Radar (DPR), (Provided by JAXA)

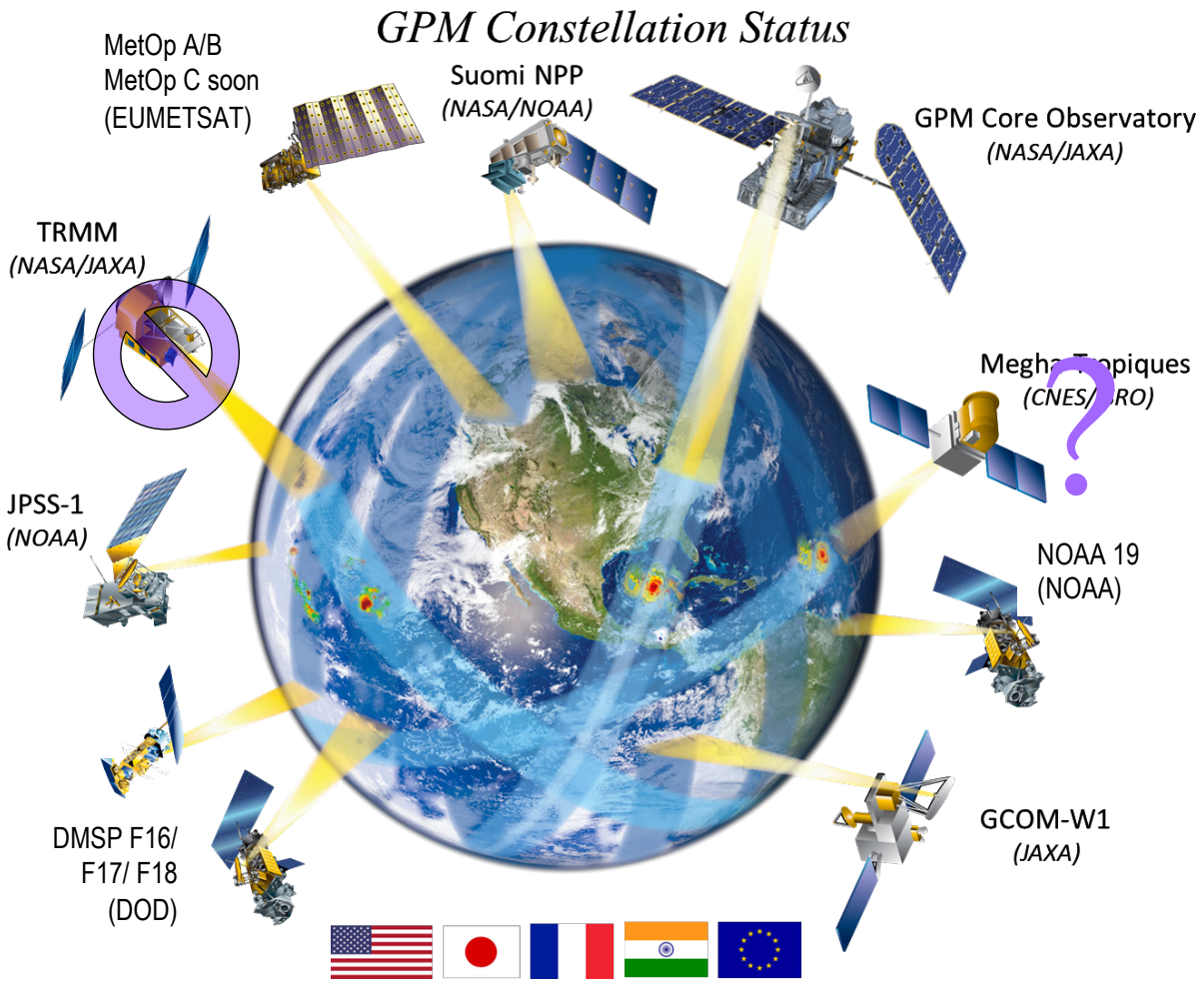
- KuPR similar to TRMM, KaPR added for GPM
- Provides 3D measurements of precipitation structure, precipitation particle size distribution
- High spatial resolution (5km horiz.; 250m vertical)

The GPM Constellation

GLOBAL PRECIPITATION MEASUREMENT

GPM Constellation:

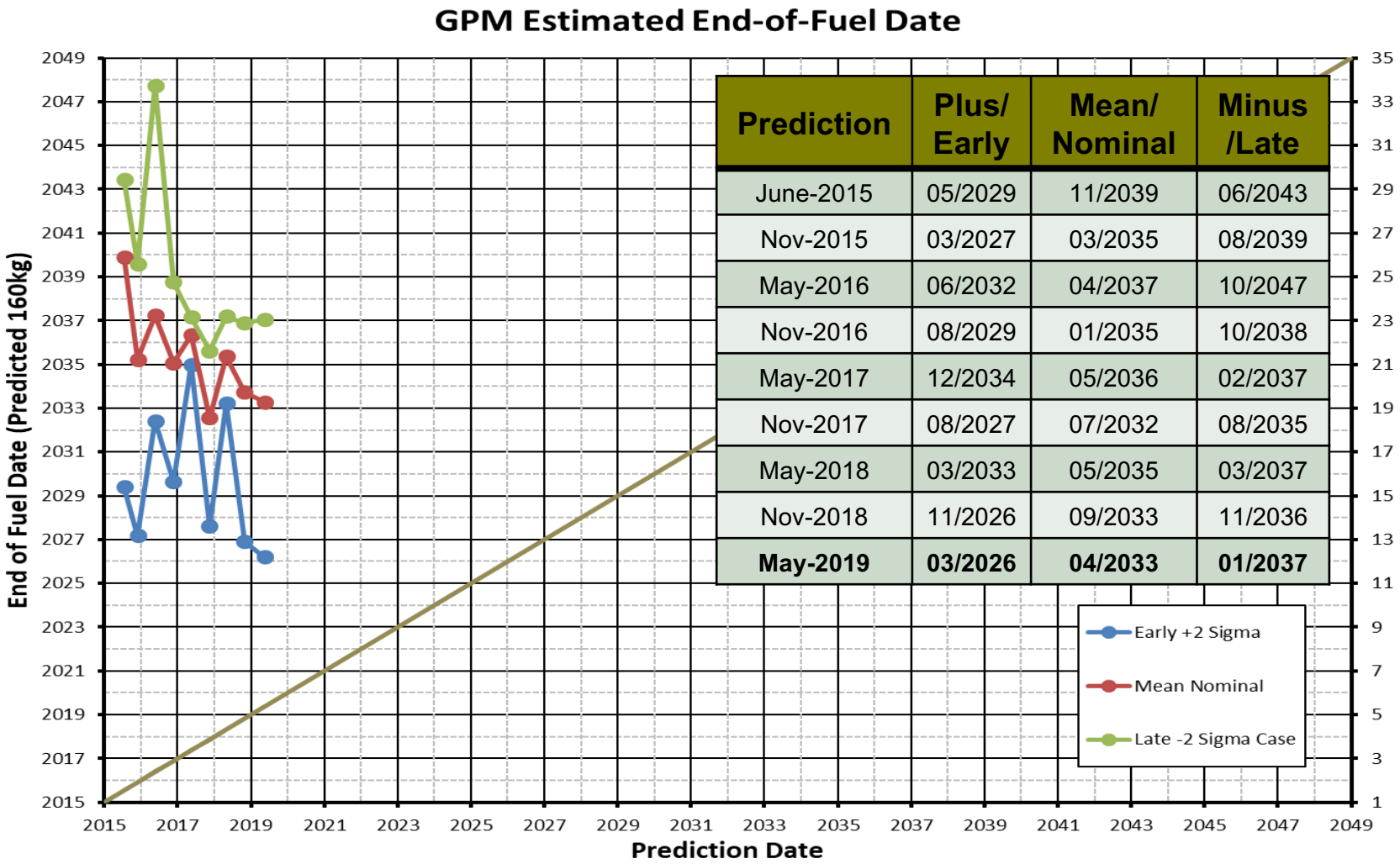
- Improved knowledge of water cycle variability
- Improved prediction of floods, landslides & freshwater resources



11 sensors in current constellation

Fuel Predictions to Date

Current end-of-fuel date is April 2033



Prediction	Plus/ Early	Mean/ Nominal	Minus /Late
June-2015	05/2029	11/2039	06/2043
Nov-2015	03/2027	03/2035	08/2039
May-2016	06/2032	04/2037	10/2047
Nov-2016	08/2029	01/2035	10/2038
May-2017	12/2034	05/2036	02/2037
Nov-2017	08/2027	07/2032	08/2035
May-2018	03/2033	05/2035	03/2037
Nov-2018	11/2026	09/2033	11/2036
May-2019	**03/2026**	**04/2033**	**01/2037**

Mission Status

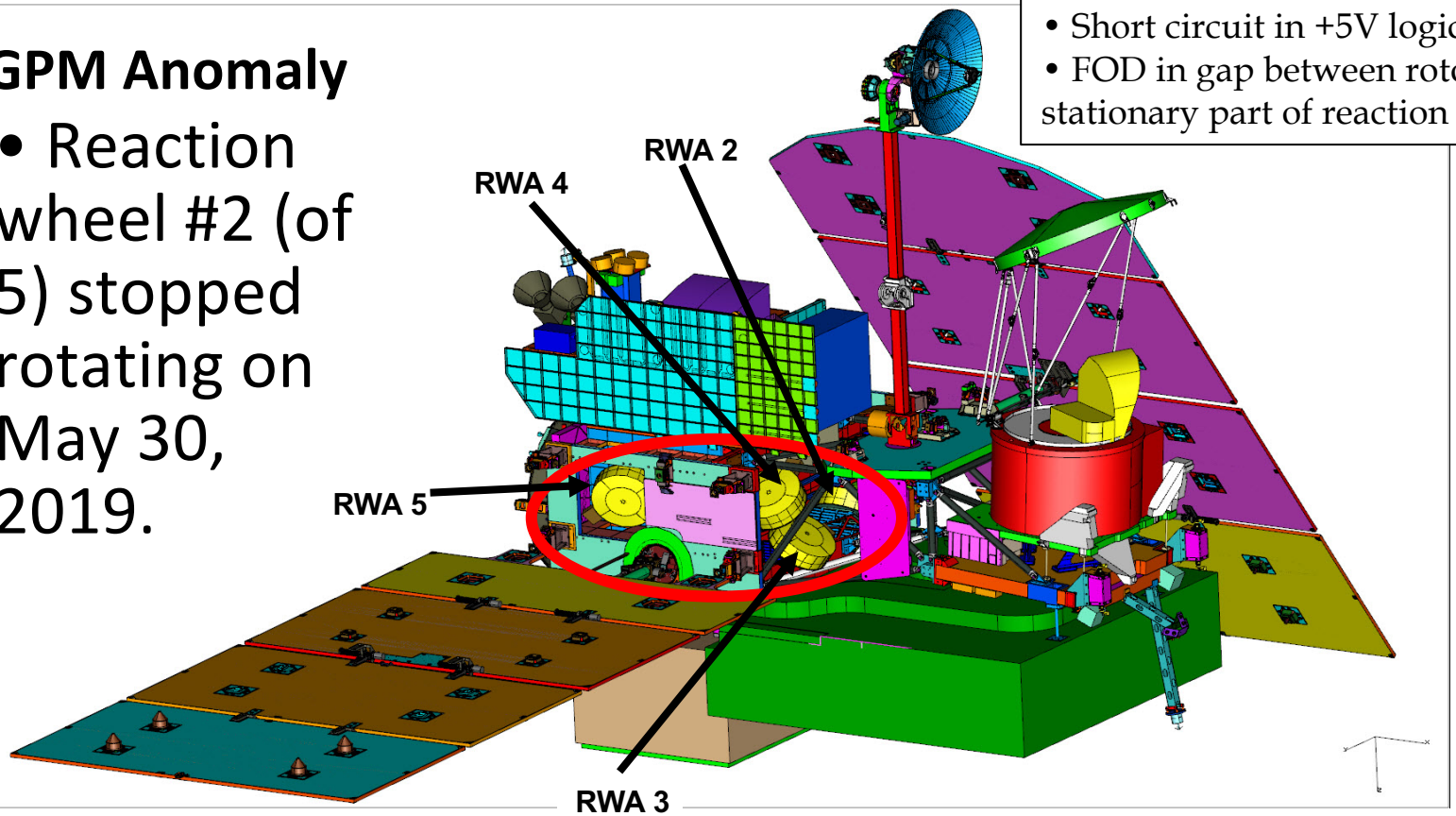
Spacecraft and instrument status: All systems are fully functional

Algorithm status: V05 (radiometers), V06 (radar, combined, IMERG, LH), next reprocessing ~2021

Possible causes:
- Increased drag in ball bearings
- Resistive short in ceramic capacitor
- Short circuit in +5V logic device
- FOD in gap between rotor and stationary part of reaction wheel

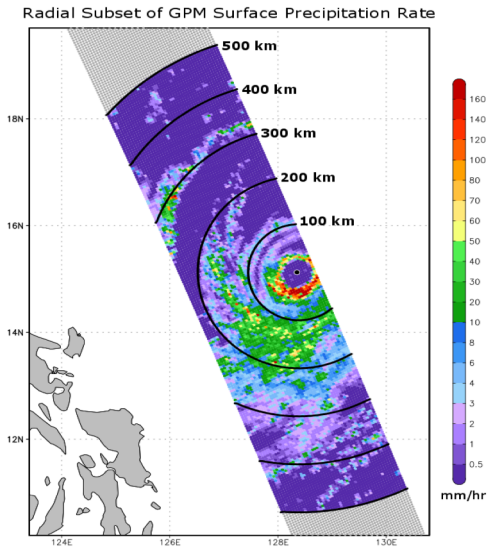
GPM Anomaly

- Reaction wheel #2 (of 5) stopped rotating on May 30, 2019.

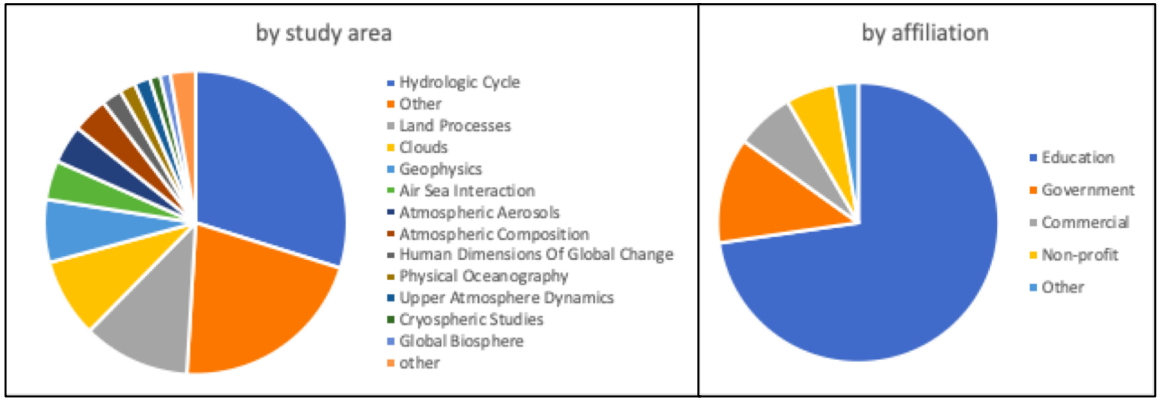


GES DISC support to PMM - current status

- V06B IMERG (Early, Late, Final) made available in June;
  - Immediately notified the users who downloaded V06A
- Services updates:
  - V06B IMERG in Giovanni for visual and analysis exploration
  - Level 2 GPM sub-setter (average download **volume reduction >90%**)
  - Level 3 re-gridder (re-grids to 33 different gridding schemes)
- Services available:
  - OPeNDAP: Hyrax, THREDDS, GDS; OGC WMS
- User assistance and outreach
  - On-site science expertise providing personal assistance and numerous data recipes on how to understand and access PMM data.
  - User training including webinars, workshops
- ICSU World Data System trusted repository:
  - Certified for data citation by high-impact journals (such as Nature)
  - "FAIR" practices: findable, accessible, interoperable, reusable
- FY2019 Metrics, User Profiles for GPM & TRMM):



Subset of L2 GPM-DPR within 500 km of Typhoon Mangkhut eye using GrADS.



Distribution	TRMM	GPM
Users	5918	3302
Files	41 million	71 million
Volume (TB)	113	533

GES DISC support to PMM - current status

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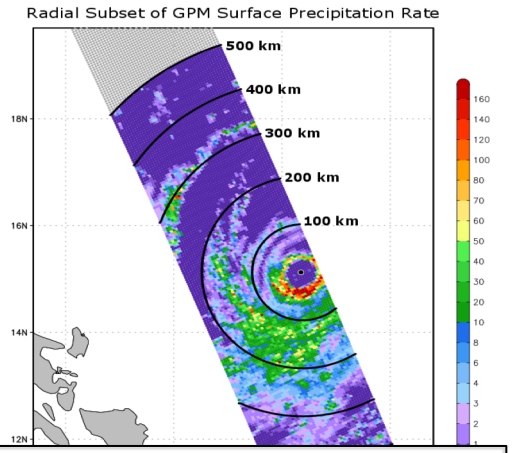
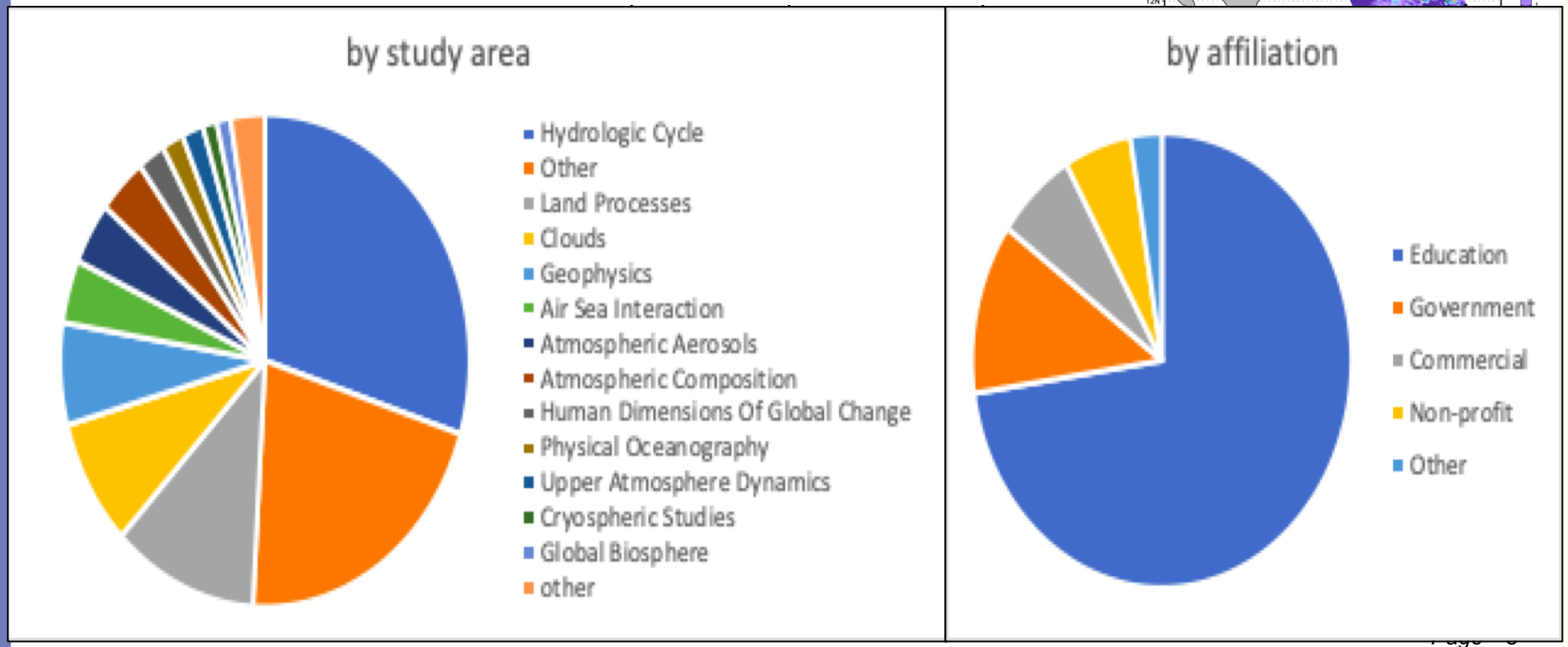
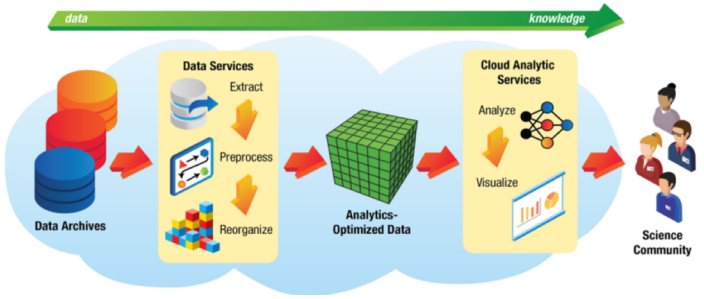




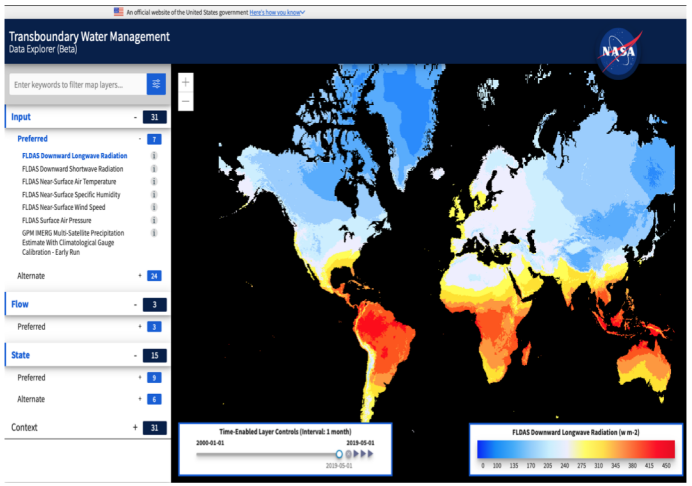
GLOBAL PRECIPITATION MEASUREMENT

GES DISC support to PMM - in development

- IMERG in the Cloud (Cumulus)
  - Co-located with other DAACs data for integrated discovery, access, analysis in the Amazon cloud
  - MERRA-2, AIRS Level 2 as well in FY20.
- Giovanni in the Cloud
  - Analytics framework for next generation data systems
  - **> 500x performance improvements** for extraction and analysis of long time series (1000s of time steps)
  - Permits third parties to add data and services to Giovanni analysis framework.
- Other services in development:
  - Time aggregation services, geoTIFF format conversion for GIS users
- Curation services:
  - Community products - PI's can provide non-mission data sets for distribution from trusted repository.
  - Paper publication mining using machine learning to determine how GPM, TRMM products and related services are being used (collaboration with Oak Ridge, JPL).
- User Engagement:
  - Expand access to PMM data and related services to the Applications community
    - Including access through GIS platforms as part of NASA-wide effort.
    - Collaboration with ARSET in global training program related to water resource management.



Cloud Analytics Reference architecture based on Giovanni model



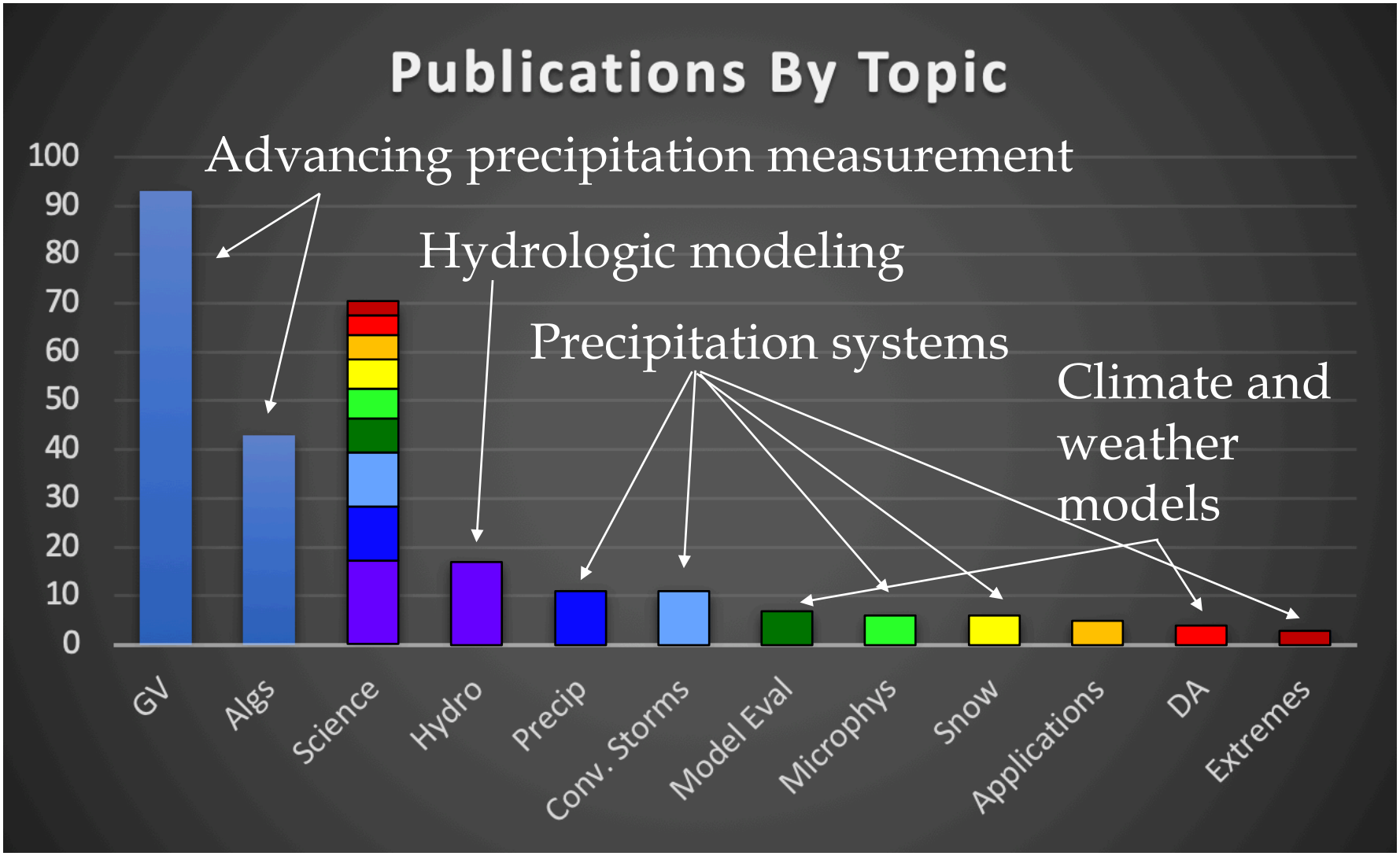
GES DISC support to NASA-led interagency trans-boundary water GIS application development.

GPM Senior Review Proposal

- Senior Review Proposal due March 2020
- Should highlight recent accomplishments toward mission objectives:
  - Advancing precipitation measurements from space (including microphysical properties and vertical structure information)
  - Improving knowledge of precipitation systems, water cycle variability, and freshwater availability
  - Improving climate modeling and prediction
  - Improving weather forecasting and 4D reanalysis
  - Improving hydrological modeling and prediction

Publications By Topic

Publications from Oct. 2017– July 2019

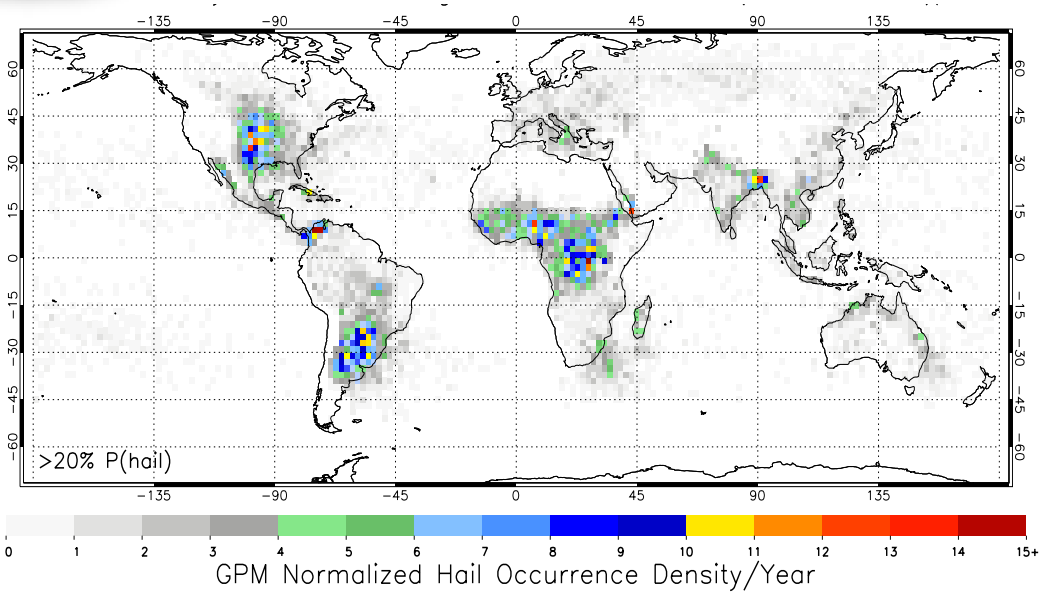


Based on Web of Science survey

GPM Senior Review Proposal

- Senior Review Proposal due March X, 2020
- Should highlight recent accomplishments toward mission objectives:
  - Advancing precipitation measurements from space (including microphysical properties and vertical structure information)
  - Improving knowledge of precipitation systems, water cycle variability, and freshwater availability
  - Improving climate modeling and prediction
  - Improving weather forecasting and 4D reanalysis
  - Improving hydrological modeling and prediction
- Science highlight to scott.a.braun@nasa.gov
- Applications highlight to dalia.b.kirschbaum@nasa.gov

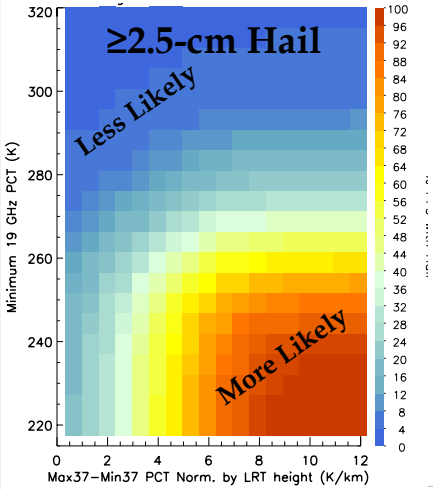
Hail Retrieval and Climatology from GPM

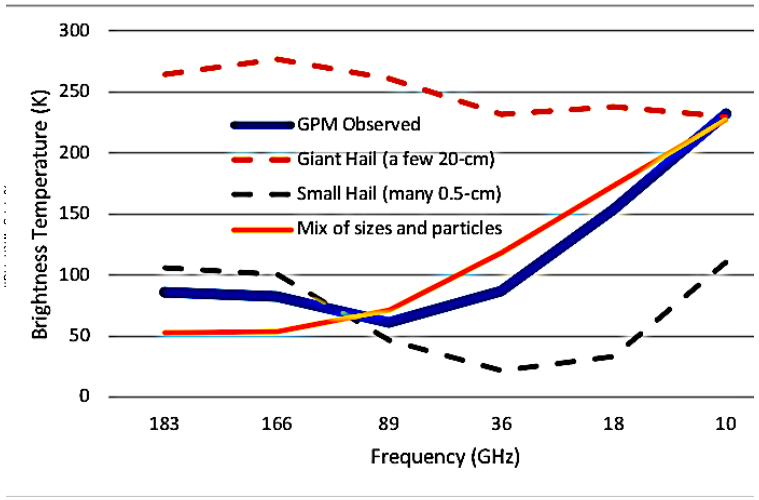


- Bang and Cecil (2019) combine TRMM and GPM 19-GHz and 37-GHz measurements to estimate the likelihood a storm has large hail
- Determined the frequency of occurrence of those storms.
- Scaling by tropopause height used to mitigate overestimation of storms in the tropics.

Above: Map of estimated frequency of large (≥2.5-cm) hail events using GPM 19 and 37 GHz channels, and tropopause height. From Bang and Cecil 2019.

Below-left: Probability of hail as a function of 19- and 37-GHz measurements, normalized using tropopause height. From Bang and Cecil 2019.





- Leppert and Cecil (2019) tested sensitivity to precipitation microphysics for a Texas hail storm with extremely low GPM-observed brightness temperatures.
- Explains why GPM measurements are not highly correlated with hail size – the number of hailstones is more important than their size.

- Should describe future directions
  - Planned future algorithm advances (from working group leads)
  - New science directions
  - New applications

Extended Mission Algorithm Objectives From 2017

2017 Senior Review Future Directions — Algorithms/Products	
Improve and reprocess the GPM-CO and GPM Constellation (IMERG) retrieval algorithms from Version 05 to Version 06	✓
Reprocess the TRMM data using the GPM-CO as a reference standard to obtain an even longer record (20+ years) of the precipitation data	✓
Develop Level 4 products providing model-assimilated precipitation analyses and analysis for downscaled precipitation estimates	X
Extend IMERG from pole to pole (currently only ±60° latitude)	✓-
Enhance the Lagrangian morphing process used by IMERG	✓
Reduce the discrepancies in over-land retrievals	?
Improve the estimates/reduce the error of falling snow and light rain retrievals	?
Fully integrate the cross-track scanning radiometers (sounders) precipitation estimates into the IMERG product	✓
Develop a new product by revising the Ka-band swath scanning operations	✓-

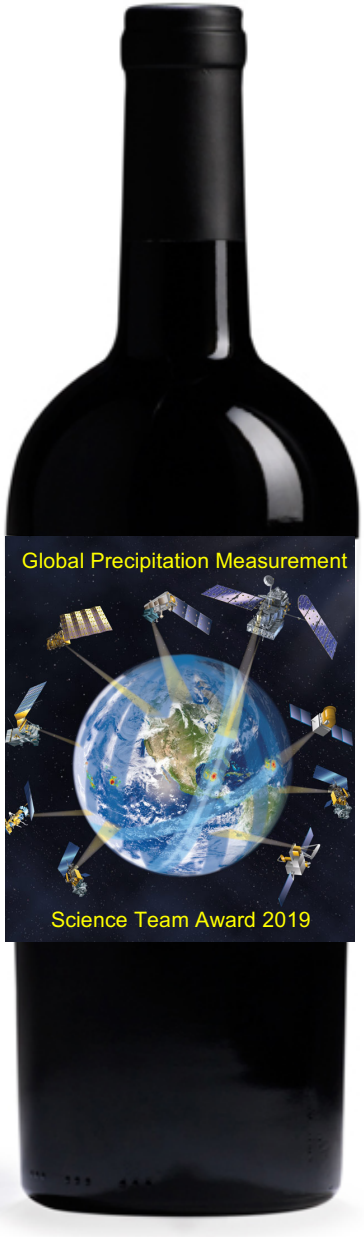
Extended Mission Science Objectives From 2017

- Increase knowledge of mean precipitation variations and intensity distributions by using GPM/TRMM observations.
  - Microphysics and physical properties of precipitation systems
  - Analysis of long-record data sets, variability in terms of ENSO and other phenomena
  - Fine-scale regional climatologies on monthly to seasonal basis
  - The development of optimal data assimilation procedures to improve climate analysis, numerical weather prediction, and hydrological prediction
- Retrieval of other variables such as winds and surface emissivity from the GPM datasets, more details on latent heating in the mid-latitudes, and better assessments of falling snow properties
- Improving the reliability of spaceborne estimates of precipitation over orographic surface features

GPM Senior Review Proposal

- Senior Review Proposal due March X, 2020
- Should describe future directions
  - Planned future algorithm advances (from working group leads)
  - New science directions
  - New applications
- Algorithm/working group leads: Describe in bullet form your top 1-3 objectives for the next 3 years, with text providing background/explanation
- Science & applications users: Send recommendations for priority science areas, with text providing background/ explanation

Today's Science Team Award



Award Person(s) or Team(s) that significantly enhance PMM science

2019 Winners…

Clair Pettersen
Mark Kulie

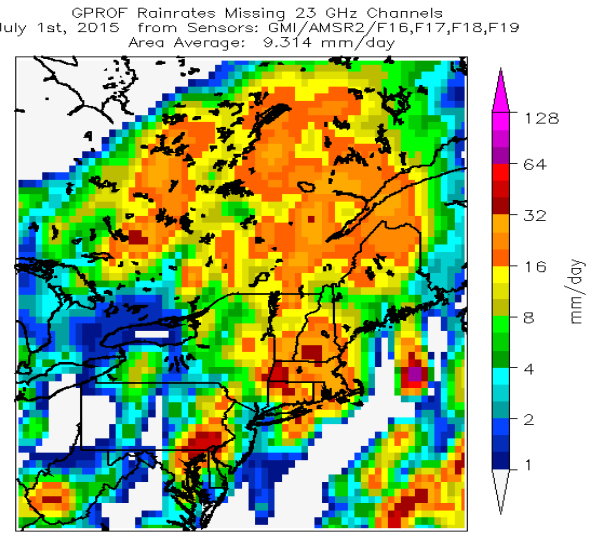
Summary

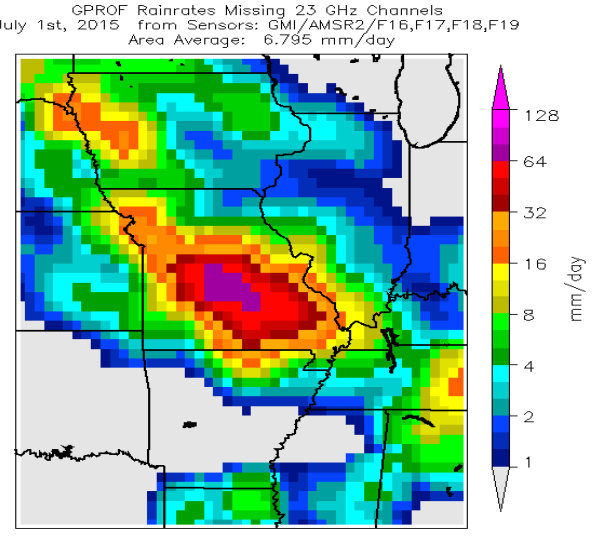
- GPM's systems are all fully functional, with fuel to potentially last until ~2033.
- GESDISC tools available and in development. Feedback welcome.
- Senior Review Proposal due March 2020. WE NEED YOUR INPUT!

- Extra slides on 23.8 GHz interference by 5G

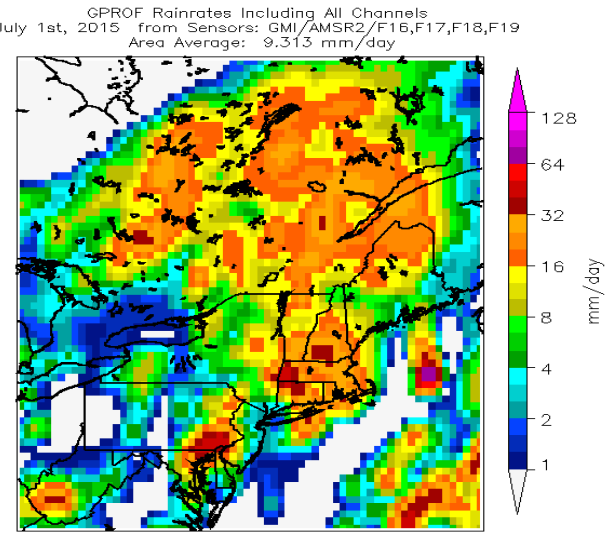
Two Heavy Rain Events

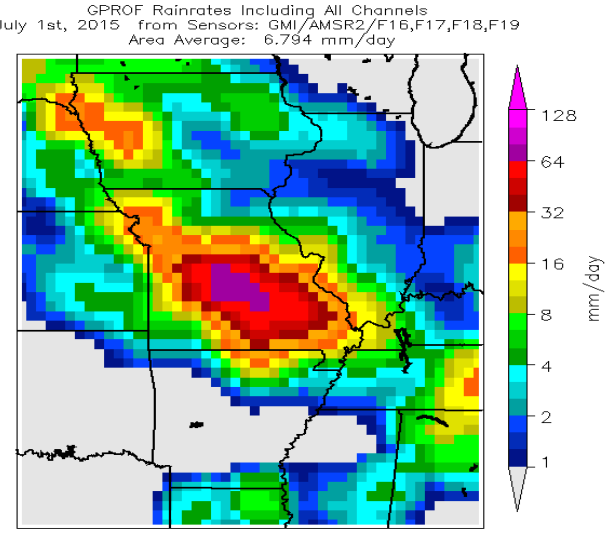
Derived rain rate No 23.8 GHz data



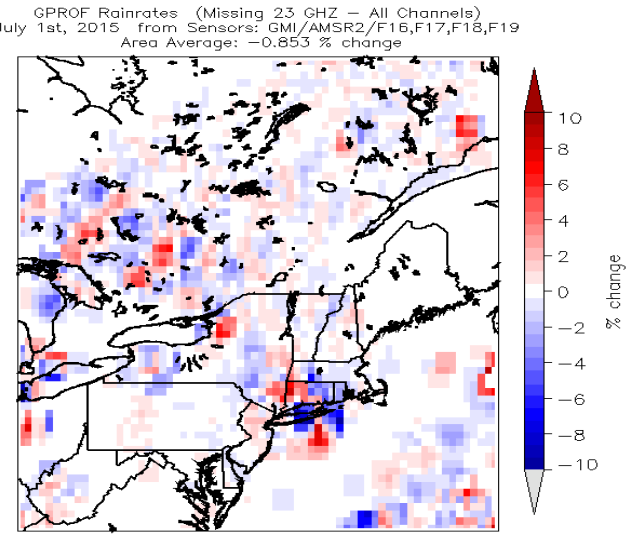


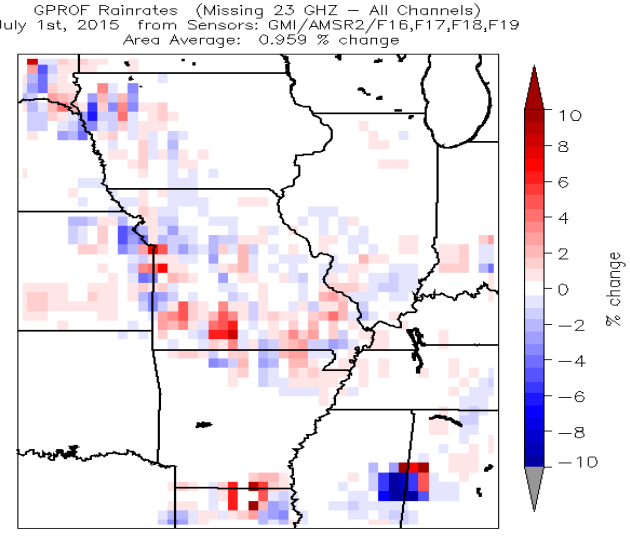
Derived rain rate Includes 23.8 GHz data





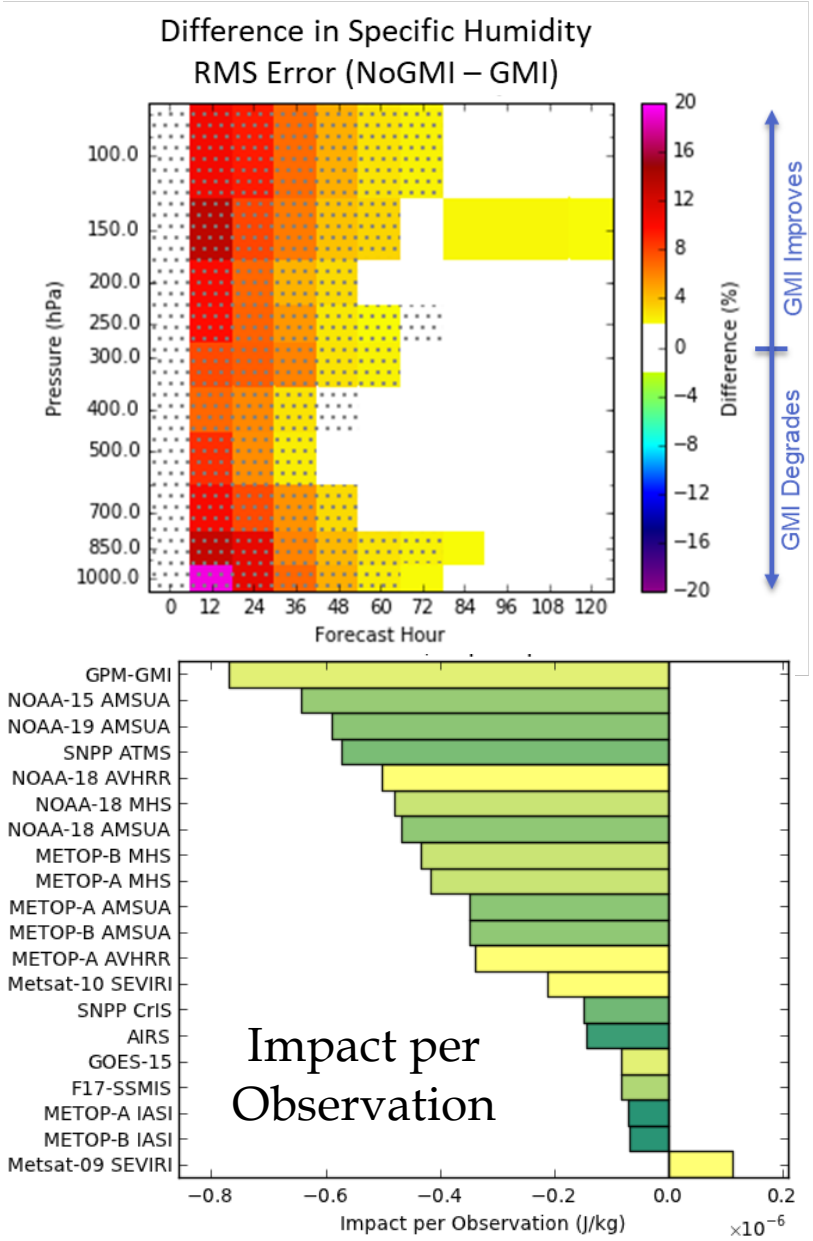
Percentage differences between the two estimates





All-Sky GPM Data in GEOS Weather Forecasts

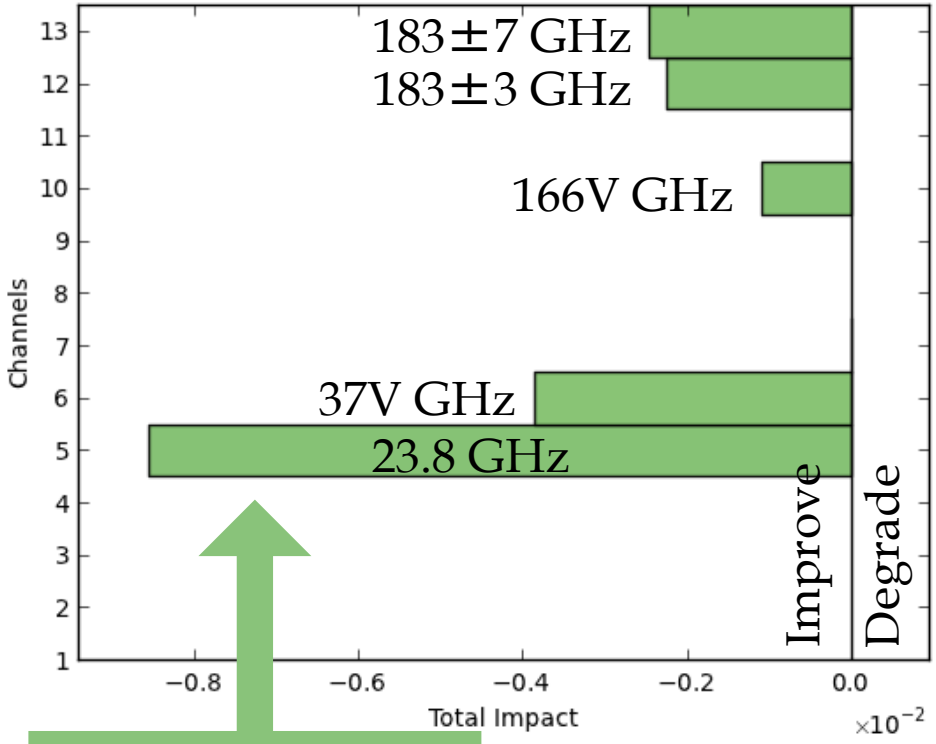
- Largest impact of GMI radiances in the Tropics
  - Specific humidity improved in short term (0-72 hour) forecasts (top, hatched indicates significance)
  - Similar improvements occur in tropical mid and lower tropospheric temperature and winds (not shown)
- Other modeling and initialization improvements included in the GEOS upgrade extend these improvements into the medium range
- **GMI is seen to have the highest impact per observation of all the radiance observation types**, and the total impact of GMI (bottom) is comparable to a single Microwave Humidity Sounder instrument (not shown)



Min-Jeong Kim (GMAO/GESTAR)

Impact of 23.8 GHz on 24 Hour Forecasts

GPM Microwave Imager FSOI by Band
1 Aug – 30 Nov 2018



The FSOI metric can be used to illustrate the importance of the 23.8 GHz band

- For FSOI, negative (positive) values indicate that the observations contributed to a forecast error reduction (increase)
  - *Negative is good*
- Of the six bands used in our weather forecasting system, the 23.8 GHz band accounts for 47% of the total forecast impact from GPM/GMI

FSOI=Forecast Sensitivity-Observation Impact

Courtesy of W. McCarty

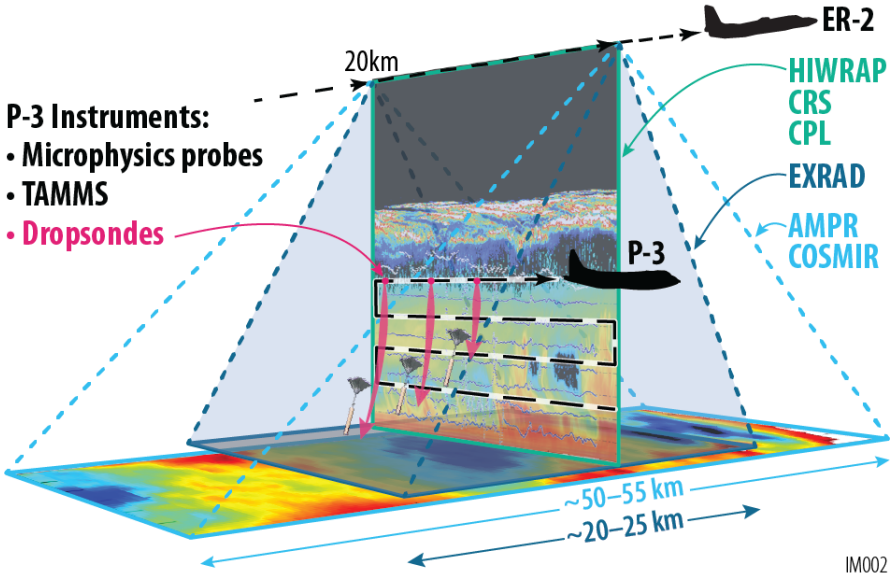
Investigation of Microphysics and Precipitation or Atlantic Coast-Threatening Snowstorms (IMPACTS)

– PI Lynn McMurdie, University of Washington, deputy PIs G. Heymsfield (GSFC), J. Yorks, and S. Braun

IMPACTS Objectives

1. **CHARACTERIZE** the spatial and temporal scales and structures of snow bands in Northeast US winter storms
2. **UNDERSTAND** the dynamical and microphysical processes that produce the observed structures
3. **APPLY** this understanding of the structures and underlying processes to improve remote sensing and modeling of snow

IM055



IM002

GPM funded additions:

- Dual-frequency, dual-polarized, Doppler radar (D3R) near UCONN
- Pluvio, disdrometer, other instruments